Concatenated schemes of Reed-Solomon and convolutional codes for GNSS

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Introduction

- The reliable transmission of the global naviation satellite system (GNSS) signals are a essential requirement affecting navigation service quality

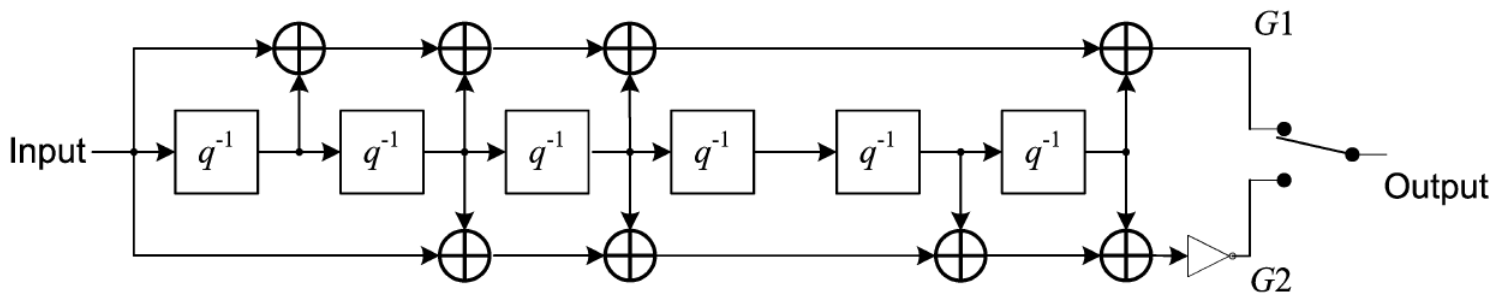
- However, the signals suffer a high free-space propagation losses with noise and interferences

- Therefore, forward error correction (FEC) plays an important role to overcome the transmission error

Introduction

	Signal	Forword error correction	Input bits
GPS	L1C/A	(32,26,4) Extended Hamming	26
		(51,9) BCH	9
	L1C	(1200,600) LDPC + CRC	576 + 24
		(548,274) LDPC + CRC	250 + 24
	L2C	(171,133) Conv. + CRC	276 + 24
	L5	(171,133) Conv. + CRC	276 + 24
QZSS	L1S	(171,133) Conv. + CRC	226 + 24
GALILEO	E1(even)	(171,133) Conv. + CRC	90 + 24 + 6(tail)
	E1(odd)	(171,133) Conv.	114 + 6(tail)
	E5b(even)	(171,133) Conv.	114 + 6(tail)
	E5b(odd)	(171,133) Conv. + CRC	90 + 24 + 6(tail)
	E5a	(171,133) Conv. + CRC	224 + 24 + 6(tail)
	E6	(171,133) Conv. + CRC	462 + 24 + 6(tail)

Related work



- A ½ rate convolutional code (CC) scheme is used for most GNSS signals in short frame length

- CC is simply implemented using shift register

- But it is vulnerable to <u>burst errors</u>

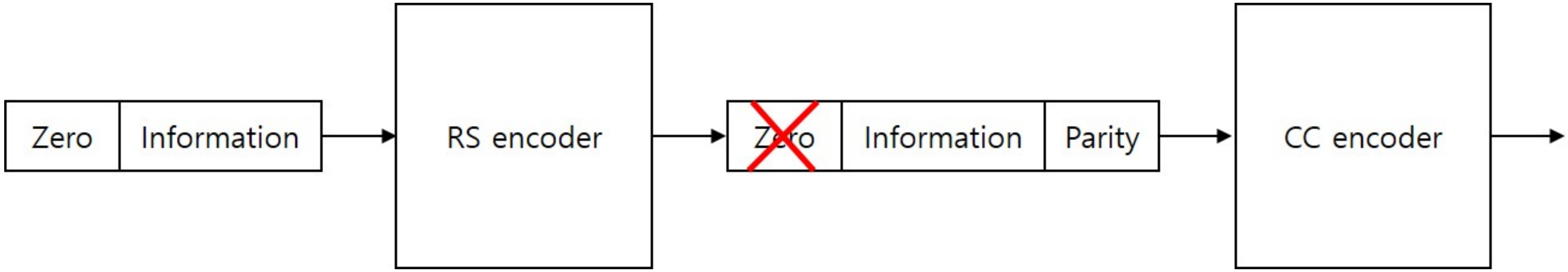
Related work

- To overcome such vulnerability, the scheme of concatenated convolutional codes are used

- Typical concatenated convolutional codes are the <u>concatenated Reed-Solomon/convolutional codes</u>

- The burst errors at the output of the Viterbi decoder are corrected by the symbol error correcting Reed-Solomon (RS) codes

Proposed scheme



- We propose a concatenated scheme of RS codes and CC applying the shortening method
- To match the symbol length of the RS codes, we add zero bits
- After RS encoding, the encoded bits except zero bits are entered into the CC encoder

Proposed scheme

K	$300\ bits$	$450\ bits$	$600\ bits$
$Zero$	$1{,}708\ bits$	$1{,}542\ bits$	$1{,}376\ bits$
$K + Zero$	$2{,}008\ bits$	$1{,}992\ bits$	$1{,}976\ bits$
$Parity$	$32\ bits$	$48\ bits$	$64\ bits$
T	$4\ symbols$	$6\ symbols$	$8\ symbols$
N	$2{,}040\ bits$		
r_{total}	0.4518		

- The codeword through the CC encoder is transmitted over the AWGN channel

- A code rate can be calculated as follows;

$$r_{total} = r_{RS} \cdot r_{CC}$$

Proposed scheme

- Let N be a codeword symbol length of RS code over $\mathrm{GF}(2^m)$, K be a length of information bits, and T be an error correcting capability

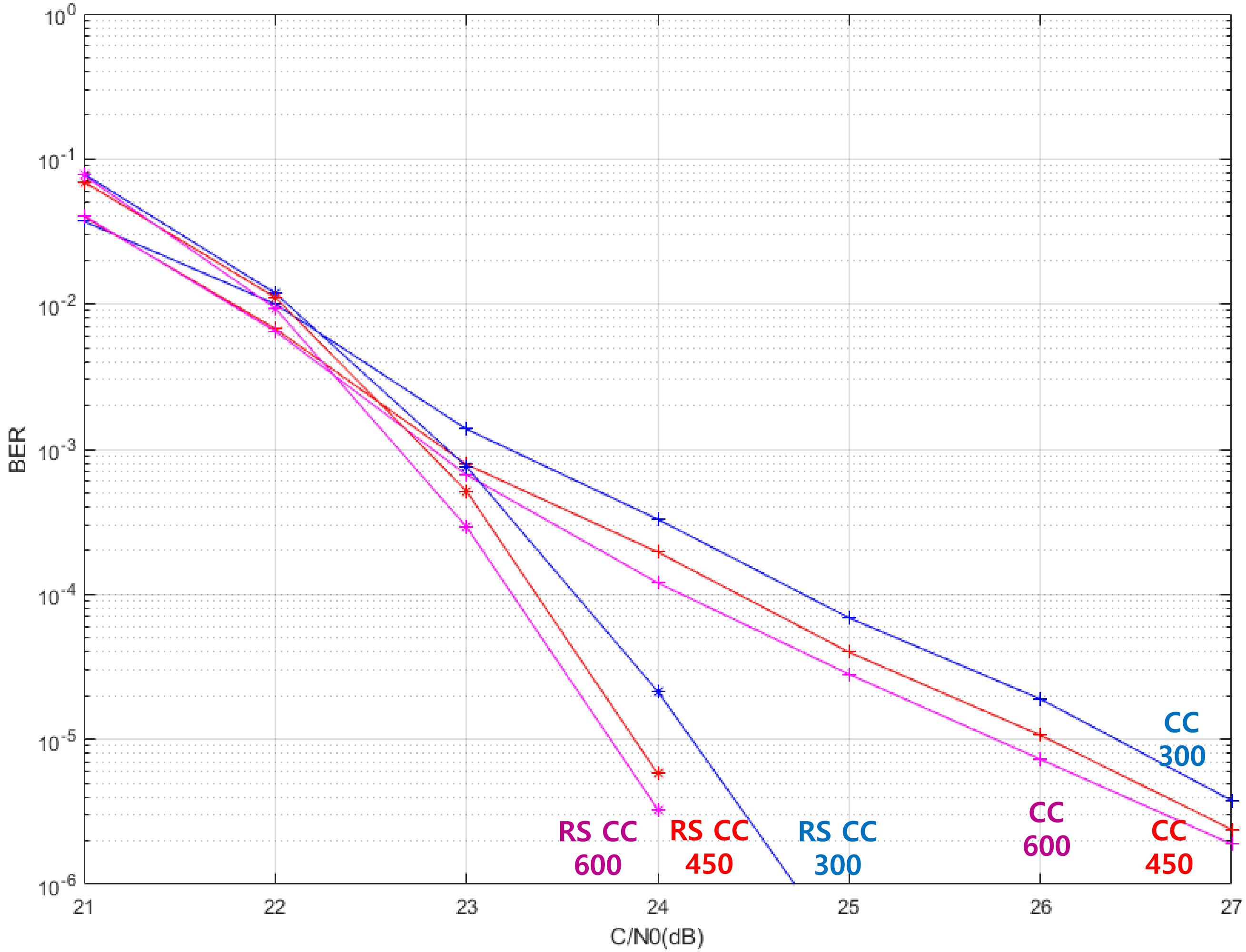
- To acheive the code rate of existing GNSS open service message, we select RS codes with very high code rate, while we fix $r_{CC} = 0.5$

- The number of zero bits that we add for concatenated scheme is calculated as follows;

$$(\#\ of\ zero\ bits) = m(N - 2 \cdot T) - K$$

Simulation results

$Assume\ 100\ sps$



Simulation results

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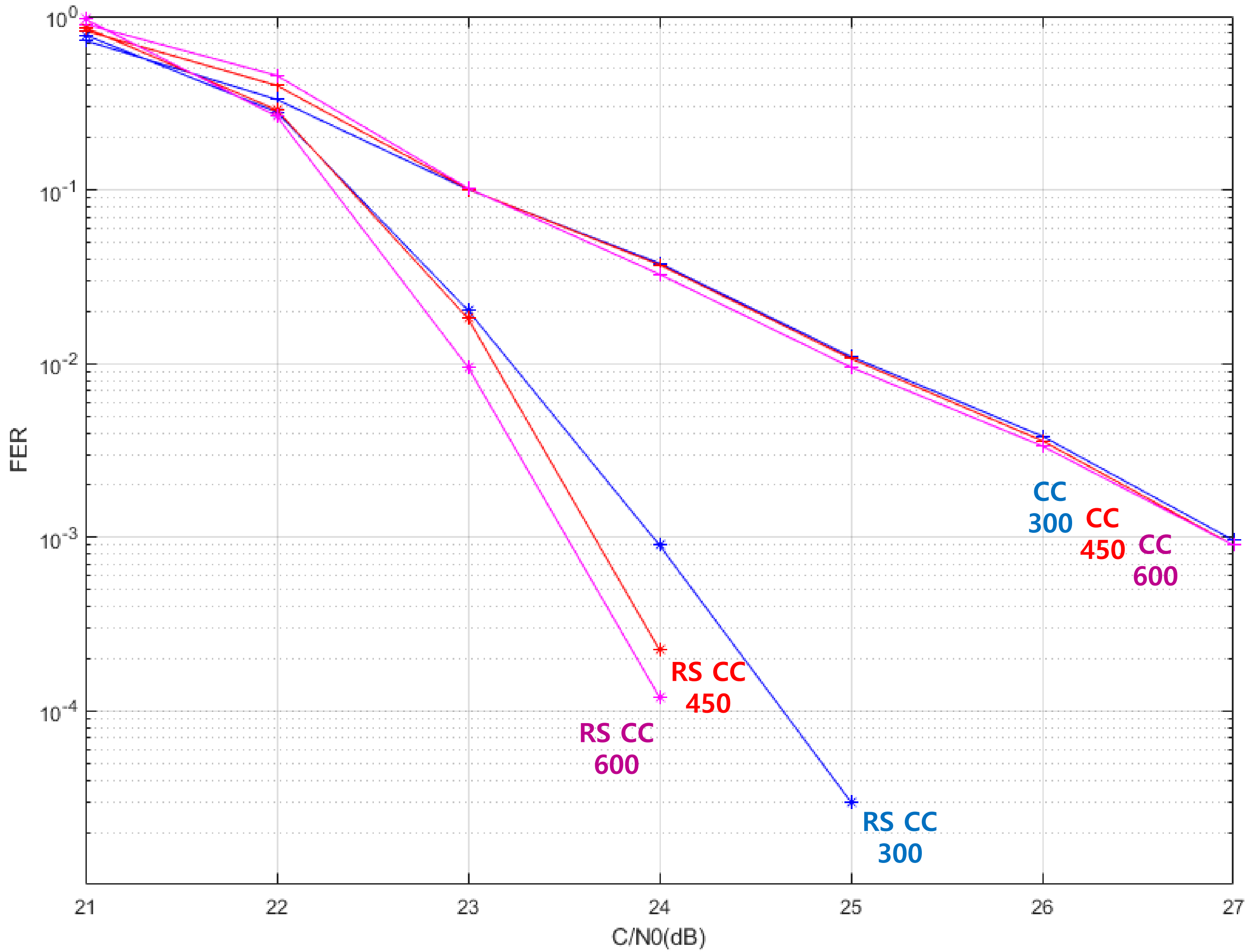

Conclusion

- We simulated the proposed concatenated scheme of RS codes over $GF(2^m)$ and a ½ rate CC

- The results showed that the concatenated RS-CC codes have coding gain compared to CC despite of lower code rate

Thank you